ATTENUATION & ATTENUATOR

Definitions

Attenuation is the reduction in amplitude and intensity of a signal.

An **attenuator** is an electronic device that reduces the amplitude or power of a signal without appreciably distorting its waveform.

Basics

Attenuation is the reduction in amplitude and intensity of a signal. Signals may be attenuated exponentially by transmission through a medium, in which case attenuation is usually reported in dB with respect to distance traveled through the medium. Attenuation can also be understood to be the opposite of amplification. Attenuation is an important property in telecommunications and ultrasound applications because of its importance in determining signal strength as a function of distance. Attenuation is usually measured in units of decibels per unit length of medium (dB/cm, dB/km, etc) and is represented by the attenuation coefficient of the medium in question.

Ultrasound

One area of research in which attenuation figures strongly is in ultrasound physics. Attenuation in ultrasound is the reduction in amplitude of the ultrasound beam as a function of distance through the imaging medium. Accounting for attenuation effects in ultrasound is important because a reduced signal amplitude can affect the quality of the image produced. By knowing the attenuation that an ultrasound beam experiences travelling through a medium, one can adjust the input signal amplitude to compensate for any loss of energy at the desired imaging depth.

- *Ultrasound attenuation* measurement in heterogeneous systems, like emulsions or colloids yields information on particle size distribution. There is ISO standard on this technique .
- *Ultrasound attenuation* can be used for extensional rheology measurement. There are acoustic rheometers that employ Stokes' law for measuring extensional viscosity and volume viscosity.

Attenuation coefficient

Attenuation coefficients are used to quantify different media according to how strongly the transmitted ultrasound amplitude decreases as a function of frequency. The attenuation coefficient (α) can be used to determine total attenuation in dB/cm in the medium using the following formula:

$$\text{Attenuation(dB)} = \alpha(\text{dB/MHz} * \text{cm}) \times l(\text{cm}) \times \text{f(MHz)}$$

As this equation shows, besides the medium length and attenuation coefficient, attenuation is also linearly dependent on the frequency of the incident ultrasound beam. Attenuation coefficients vary widely for different media. In biomedical ultrasound imaging however, biological materials and water are the most commonly used media. The attenuation coefficients of common biological materials at a frequency of 1 MHz are listed below:

Material	**α(dB / MHz * cm)**
Lung	41
Bone	20
Kidney	1.0
Liver	0.94
Fat	0.63
Blood	0.18
Brain	0.85
Water	0.0022

There are two general ways of acoustic energy losses: absorption and scattering, for instance light scattering. Ultrasound propagation through homogeneous media is associated only with absorption and can be characterised with absorption coefficient only. Propagation through heterogeneous media requires taking into account scattering .

Earthquake

The energy, with which an earthquake affects a location, depends from the running distance. The attenuation in the signal of ground motion intensity plays an important role in the assessment of possible strong ground shaking. A seismic wave loses energy as it propagates through the earth (attenuation). This phenomenon is tied up to the dispersion of the seismic energy with the distance. There are two types of dissipated energy:

1. geometric dispersion caused by distribution of the seismic energy to greater volumes
2. dispersion as heat

Electromagnetic

Attenuation decreases the intensity of electromagnetic radiation due to absorption or scattering of photons. Attenuation does not include the decrease in intensity due to inverse-square law geometric spreading. Therefore, calculation of the total change in intensity involves both the inverse-square law and an estimation of attenuation over the path.

The primary causes of attenuation in matter are the photoelectric effect, compton scattering and, for photon energies of above 1.022MeV, pair production.

Radiography

See Attenuation coefficient article.

Optics

Attenuation of light by cloudy water is called turbidity, and by interstellar dust, extinction (astronomy). Attenuation in glass or other solid medium is usually studied by telecommunication engineers, hence is called by the same names as the attenuation of electrical signals.

Attenuation is caused by several different factors, but primarily scattering and absorption.The scattering of light is caused due to molecular level irregularities in the glass structure.Further attenuation is caused by light absorbed by residual materials, such as metals or water ions, within the fiber core and inner cladding.Light leakage due to bending, splices, connectors, or other outside forces are other factors resulting in attenuation.Attenuation in **fibre optics**, also known as transmission loss, is the reduction in intensity of the light beam with respect to distance travelled through a transparent medium. Attenuation coefficients in fibre optics usually use units of dB/km through the medium due to the great transparency of modern optical media. The medium is usually a fibre of silica glass that confines the incident light beam to the inside. Attenuation is an important factor limiting the transmission of a light pulse across far distances, and as a result much research has gone into both limiting the attenuation and maximizing the amplification of the fibre optic light beam. Attenuation in fibre optics can be quantified using the following equation:

$$\mathrm{Attenuation(dB)} = 10 \times \log_{10}\left(\frac{\mathrm{Output\ Intensity(W)}}{\mathrm{Input\ Intensity(W)}}\right)$$

Applications

In **optical fibers**, attenuation is the rate at which the signal light decreases in intensity. For this reason, glass fiber (which has a low attenuation) is used for long-distance fiber optic cables; plastic fiber has a higher attenuation and hence shorter range. There also exist optical attenuators which decrease the signal in a fiber optic cable intentionally.

Attenuation of light is also important in physical oceanography. Here, attenuation is the decrease in light intensity with depth due to absorption by water molecules and scattering by suspended particulates. This same effect is an important consideration in weather radar as rain drops absorb a part of the emitted beam that is more or less significant depending on the wavelength used.

The attenuation of photons, particularly of those in the x-ray spectrum, is important in the field of medical physics. Due to the damaging effects of high energy photons, it is necessary to know how much energy is deposited in tissue during diagnostic treatments involving such radiation. Additionally gamma radiation is used in cancer treatments where it is important to know how much energy will be deposited in healthy and in tumorous tissue.

Radio

Attenuation is an important consideration in the modern world of wireless telecommunication. People are daily affected by it as they rely more and more on mobile phones, television, satellite communication, and wireless internet. Attenuation limits the range of radio signals and is affected by the materials a signal must travel through (e.g. air, wood, concrete, rain). See the article on path loss for more information on signal loss in wireless communication.

Attenuator

An **attenuator** is an electronic device that reduces the amplitude or power of a signal without appreciably distorting its waveform. Attenuators are usually passive devices made from resistors. The degree of attenuation may be fixed, continuously adjustable, or incrementally adjustable.

Low level attenuators

An attenuator is effectively the opposite of an amplifier, though the two work by different methods. While an amplifier provides gain, an attenuator provides loss, or gain less than 1.

A fixed electrical attenuator is often called a **pad**, especially in telephony and audio engineering. The input and output impedances of an electrical attenuator are usually matched to the impedances of the signal source and load, respectively.

A line-level attenuator in the preamp or a power attenuator after the power amplifier uses electrical resistance to reduce the amplitude of the signal that reaches the speaker, reducing the volume of the output. A line-level attenuator has lower power handling, such as a 1/2-watt potentiometer. A power attenuator has higher power handling, such as 10 or 50 watts.

Power attenuators

In audio electronics, attenuators are used as a dummy load by sending all of the power to the resistor and none to the speaker, in order to silence or reduce the output volume of an audio amplifier (for example, a guitar amplifier). Silencing an amplifier is useful for biasing the positive and negative signal crossover, for running bench tests such as measuring the amplifier's maximum output wattage, and for adding line-level effects between a guitar amplifier and a guitar speaker.

Source: http://www.juliantrubin.com/encyclopedia/electronics/attenuation.html